



### **Tests of nanosatellites**

Denis Avariaskin

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# Working conditions and factors affecting spacecraft in flight

Rocket Flight



Features: Short duration of the stage (about 15 minutes) Large vibration loads

#### Soyuz 1st stage separation: Boosters B, V, G, D separation









Hazards: Failure from resonant frequencies. Destruction from shock.

# Working conditions and factors affecting spacecraft in flight





#### Space flight stage



#### Features:

Long duration of the stage (duration of active existence) Influence of outer space factors

- weightlessness
- vacuum
- solar and cosmic radiation

# Vibrodynamic testing of a nanosatellite

### Preparation and launch of the Soyuz rocket



#### Vibrodynamic test types

### Modes of vibration tests:

- sinusoidal vibration;
- random vibration;
- shock loads.



# Vibrodynamic testing of a nanosatellite

Modes of vibration tests:

- sinusoidal vibration;
- random vibration;
- shock loads.

Features of the stand:

- The frequency range: 11.6 ... 4000 Hz;
- Amplitude of test object motion:
  - 5 ... 23 mm;
- Maximum weight of a test object: 50 kg.







# **Thermal Vacuum Testing**



The size of working zone, mm <sup>3</sup>	500x500x500
The range of thermoplate temperature regulation, °C	-70200
The accuracy of temperature maintenance, °C	±0,5
The thermoplate temperature uniformity, °C	±2
The minimum residual pressure, mm Hg	1x10 <sup>-6</sup>

Two factors: Temperature change when entering the shade; Lack of atmosphere.

### <u>УП-125 ТХД</u>



# Thermal Vacuum Testing

### SamSat-QB50 Tests



#### Test of the CubeSat thruster



# Stand to simulate the earth's magnetic field

The stand performances:

- the range of generating magnetic field:  $\pm 150 \ \mu T$ ;
- the accuracy of the magnetic field: >90%;
- $\bullet$  the intensity of the solar radiation:1400  $W/m^2.$

The stand is equipped with:

- the Earth magnetic field simulator,
- the Sun simulator,
- the air supported platform,
- the movable stellar sky simulator.









### Robotic arm



### M-10iA/10M

The weight of tested object:
<10 kg;</li>
Controlled axes - 6;
Repeatability (mm) ± 0.03.
Max. reach (mm) - 1422.



# Robotic arm



### Equipment for determining the moments of inertia

![](_page_10_Picture_1.jpeg)

Equipment is designed to determine the center of mass and the main moments of inertia

#### **Specifications**

- maximum sizes of objects
- 350 x 150 x 150 mm
- mass range of objects
- 0.5 ... 10 kg

# Equipment for determining the moments of inertia

### Torsional period

$$T = 2\pi \sqrt{\frac{I}{G}} \rightarrow I = \frac{T^2 G}{4\pi^2}$$

T – oscillation period, I – moment of inertia, G – torsional stiffness

### Steiner-Huygens theorem

$$I = I_c + m_{NS}r^2$$

### CubeSat Mass Center:

![](_page_11_Figure_7.jpeg)

$$y_{C} = \frac{(T_{3}^{2} - T_{1}^{2})G}{8\pi^{2}am_{NS}} - \frac{a}{2}$$

![](_page_11_Figure_9.jpeg)

$$I_{CZ} = \frac{T_1^2 G}{4\pi^2} - I_0 - m_{NS} \left( x_C^2 + y_C^2 \right)$$

- $m_{NS}$  CubeSat Mass
- r distance from the axis of rotation to the center of mass
- $I_0$  moment of inertia rig
- $I_c$ -moment of inertia about an axis passing through the center of mass

# Functional testing and final assembly

Tests

Final assembly

![](_page_12_Picture_3.jpeg)

### Documentations

1.Program test method - a document which consists of two parts: the test program and test method.

1.1. The test program describes which modes and how the test should be conducted.

1.2. The test method describes in detail the process of testing on the bench, starting with the installation of the test object on the stand and ending with the process of dismantling the test object from the stand, taking into account the characteristics of this stand.

2. Test report - a document that contains information about testing without analyzing the results, contains only raw information about testing.

3. Test report - a document that contains the findings of the test, and the processed information from the test bench and test object.